



# BIOACCUMULATION OF THE AGRICULTURAL PESTICIDE ENDOSULFAN BY PHYTOPLANKTON AND ASSOCIATED FOOD WEB EFFECTS



M.E. DeLorenzo<sup>1</sup>, S.A. Lund<sup>1</sup>, E.D. Strozier<sup>1</sup>, L.A. Taylor<sup>2</sup>, G.I. Scott<sup>1</sup>

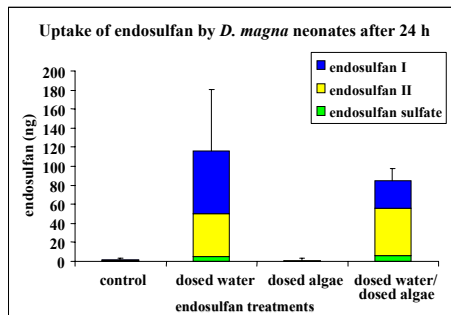
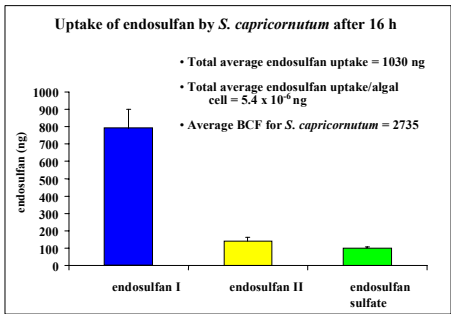
<sup>1</sup>National Ocean Service, Center for Coastal Environmental Health & Biomolecular Research, Charleston, SC

<sup>2</sup>Pacific Union College, Angwin, CA

## ABSTRACT

Agricultural pesticide runoff in southeast coastal regions is a critical issue, while studies involving pesticide effects on microorganisms are limited. Having a high surface area:volume ratio, plankton have significant potential for pesticide uptake and related toxicity. Organochlorine insecticides, such as endosulfan, preferentially partition out of water, into sediments and tissues. Accumulation of pesticides by phytoplankton and zooplankton at the base of the aquatic food web may increase the persistence of pesticides in aquatic ecosystems and lead to higher trophic level effects. This study investigated the potential of the phytoplankton species, *Selenastrum capricornutum* (freshwater green alga) to sequester the widely used agricultural pesticide, endosulfan. We also examined the degree to which endosulfan is accumulated by *Daphnia magna* (freshwater cladoceran) via water and via food (endosulfan-contaminated *S. capricornutum*). An average bioconcentration factor (BCF) of 2735 was determined for *S. capricornutum* exposed to 100 µg/L endosulfan for 16 hours. Both parent isomers (endosulfan I and endosulfan II) and the primary degradation product (endosulfan sulfate) were detected in the algal extract. An average BCF of 3259 was determined for *D. magna* in a 100 µg/L endosulfan water-only exposure. There was negligible uptake of endosulfan by *D. magna* feeding on contaminated algae (BCF~0). Endosulfan was rapidly accumulated and concentrated from water by *S. capricornutum* and *D. magna* neonates. Endosulfan contained in phytoplankton, however, was not bioaccumulated by zooplankton. These findings may prove useful in assessing ecosystem risk, since water concentration alone allows prediction of plankton BCF.

## RESULTS



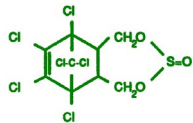
Endosulfan Bioaccumulation by <i>D. magna</i>		
	Calculated using dry weight	Calculated using lipid weight
Average BCF <sub>[water]</sub>	3259	75089
Average BAF <sub>[algae]</sub>	0.015	0.015
Estimated BAF <sub>[water + algae]</sub>	3259	75089

☆ Uptake from food was negligible

Comparison of Results to Other Endosulfan Studies			
Organism	Exposure	BCF	Citation
phytoplankton			
<i>S. capricornutum</i>	100ug/L:16h	2735	This study
zooplankton			
<i>Daphnia magna</i>	100ug/L: 24h	3259	This study
grass shrimp			
<i>Palaemonetes pugio</i>	0.2ug/L:30d	200	Wirth, 1999
<i>Palaemonetes pugio</i>	0.16ug/L:96h	81	Schimmel, 1977
oyster			
<i>Crassostrea virginica</i>	0.2 ug/L:96h	330	Scott et al., 1999
fish			
<i>Fundulus heteroclitus</i>	0.2 ug/L:96h	330	Scott et al., 1999
<i>Lagodon rhomboides</i>	0.26 ug/L:96h	1299	Schimmel, 1977
<i>Leiostomus xanthurus</i>	0.075 ug/L:96h	895	Schimmel, 1977
<i>Mugil cephalus</i>	0.92 ug/L:96h	1344	Schimmel, 1977

## INTRODUCTION

### Endosulfan



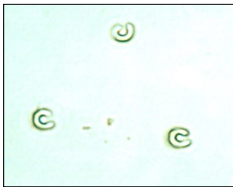
- Organochlorine insecticide
- Commonly used on fruit and vegetable crops
- 36 tons per year used in agricultural areas adjacent to Florida Bay
- Detected in surface waters at levels exceeding EPA water quality criteria

#### The objectives of this study were to:

- 1.) Determine the endosulfan bioaccumulation potential of *S. capricornutum*
- 2.) Determine the amount of endosulfan accumulated by *D. magna* via water exposure
- 3.) Determine the amount of endosulfan trophically transferred to *D. magna* via feeding on contaminated *S. capricornutum*

#### Effects of endosulfan on *S. capricornutum*

- Freshwater unicellular green alga
- Endosulfan 96 h EC<sub>50</sub> (direct cell counts) = 427.80 µg/L
- Growth rates hindered in south Florida surface water canals containing endosulfan and other pesticides



#### Effects of endosulfan on *D. magna*

- Freshwater filter-feeding cladoceran
- 24 h LC<sub>50</sub> = 366.33 µg/L
- 5 h EC<sub>50</sub> (filtration rate) = 165.57 µg/L
- 5 h EC<sub>50</sub> (ingestion rate) = 166.44 µg/L
- Reduced size, feeding efficiency, reproduction and longevity



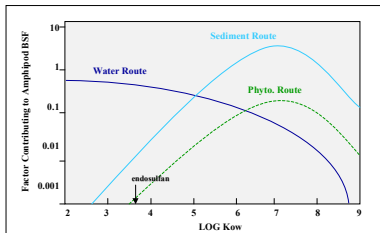
## DISCUSSION

In this study, *S. capricornutum* was found to have an average BCF of 2735. Rao and Lal (1987) also observed rapid accumulation and concentration of endosulfan by two blue-green algae, *Anabaena* and *Aulosira*. They found a linear increase in bioaccumulation with dose, indicating passive partitioning of the insecticide between medium and cellular lipid. Phytoplankton have a high cell surface area:volume ratio, allowing significant potential for chemical adsorption.

Endosulfan was not trophically transferred from phytoplankton to invertebrate grazers in this study. *D. magna* neonates did not accumulate endosulfan when exposed to the pesticide via ingestion of contaminated phytoplankton. However, *D. magna* neonates rapidly bioaccumulated and concentrated endosulfan from contaminated water, with an average BCF of 3259.

Factors affecting bioaccumulation of endosulfan by *D. magna*

Significance of log K<sub>ow</sub> value in determining contaminant uptake based on exposure route



Water is an especially important chemical exposure route for filter feeders such as *D. magna*. The large surface area:volume ratio of their filtering appendages allows pesticides found in the water to be greatly concentrated within the organism. According to Nagel and Loskill (1990), a phytoplankton BCF of 10<sup>5</sup> would be necessary for ingestion of phytoplankton to significantly affect bioaccumulation of endosulfan in *D. magna*.

Lipid content of an organism also affects pesticide bioaccumulation potential. The lipid content of *D. magna* neonates is about 4.34% while adults have a lipid content of approximately 20%. We would, therefore, expect adult *Daphnia* to accumulate endosulfan to an even greater extent than that of the neonates used in this study.

Proportionately more endosulfan II was detected in *Daphnia* tissue than would be found in the water, suggesting preferential adsorption of isomer II.

## METHODS

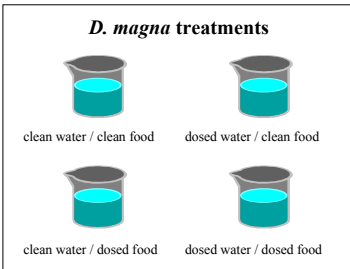
### Uptake of endosulfan by *S. capricornutum*

- 40 mL aliquots of cell culture, 3 replicates each
- Cell density = approximately 3,660,000 cells/mL
- Sublethal dosage concentration = 100 µg/L
- 16 hour exposure (8 h light, 8 h dark)
- Algae centrifuged (2500 rpm for 30 min), decanted supernatant
- Pellet resuspended in DI water, centrifuged again, repeated 2x
- Endosulfan extracted from the algal pellet using methanol and hexane.
- Gas chromatographic analysis of endosulfan levels in pellet extract and supernatant
- Dry weight determination of algal pellet



### Uptake of endosulfan by *D. magna*

- *D. magna* neonates hatched from *ephippia*
- 62 neonates per treatment (4 treatments, 3 replicates each)
- Water concentration of endosulfan = 100 µg/L
- Feeding cell density = 206,000 cells/mL (*S. capricornutum* exposed to 100 µg/L endosulfan for 16 hours)
- 24 h test period (16 h light, 8 h dark)
- Gas chromatographic analysis of neonate tissue & supernatant
- Dry weight determination of neonate tissue



## CONCLUSIONS

### Bioconcentration

- Endosulfan is rapidly accumulated and concentrated from water by *S. capricornutum* and *D. magna* neonates
- Endosulfan contained in phytoplankton is not bioaccumulated by zooplankton

### Ecological Implications

- Useful modeling tool
- Water concentration alone allows prediction of plankton BCF
- Can be used in evaluating environmental effects of endosulfan relevant to the south Florida restoration plan

### Future Research

- Examine metabolic treatment of endosulfan within the cells (sequestration, degradation)
- Determine assimilation efficiency of zooplankton grazers using radiolabeled endosulfan
- Repeat experiments using model marine species of phytoplankton and copepods
- Extend trophic transfer study to higher organisms by feeding contaminated zooplankton to fish

#### Literature Cited:

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